

DEPARTMENT OF AGRICULTURAL ENTOMOLOGY

COLLEGE OF AGRICULTURE, DAPOLI

Title of thesis : “Biology and efficacy of insecticides against Pumpkin caterpillar, *Diaphaina indica* Saunders infesting watermelon.”

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THESIS ABSTRACT

The present study was undertaken at Laboratory, Department of Agricultural Entomology, College of Agriculture, Dapoli from November 2015 to March, 2016. Simultaneously biology of pumpkin caterpillar, *Diaphaina indica* (saunders) on watermelon and pointed gourd was carried out. The freshly laid eggs were white to yellowish in colour and elongated in shape. The eggs measured 0.87 mm in length and 0.57 mm in breadth. The pre-oviposition period was 2.2 days and the oviposition period was 4.4 days. The post-oviposition period was 1.6 days. The total number of eggs laid by female in life span was 193.4. The incubation period was 4.3 days. Hatching percentage was 100 per cent. It was observed that there were five larval instars.

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The development period of larvae on watermelon was 13 days and 11 days on pointed gourd. The first instar lasted for 2 days on both watermelon and pointed gourd. The Larva measured 1.1 mm in length and 0.13 mm in head width on watermelon and 1.93 mm in length and 0.23 mm in head width on pointed gourd. The second instar lasted for 3 days on watermelon and 2 days on pointed gourd. The second instar Larva measured 4.63 mm in length and 0.33 mm in head width on watermelon and 4.17 mm in length and 0.38 mm in head width on pointed gourd. The third instar lasted for 2 days both on watermelon and on pointed gourd. The third instar Larva measured 7.22 mm in length and 0.59 mm in head width on watermelon and 7.23 mm in length and 0.50 mm in head width on pointed gourd. The fourth instar lasted for 3 days on watermelon and 2 days on pointed gourd. The fourth instar Larva measured 11.00 mm in length and 0.97 mm in head width on watermelon and 11.66 mm in length and 0.84 mm in head width on pointed gourd. The fifth instar lasted for 3 days on both watermelon and on pointed gourd. The fifth instar Larva measured 15.92 mm in length and 1.63 mm in head width on watermelon and 15.47 mm in length and 1.36 mm in head width on pointed gourd. Pre-pupa period lasted for 2.17 days on watermelon and 2.12 days on pointed gourd. The pupal period lasted for 6.71 days on watermelon and 6.19 days on pointed gourd. The pre pupa measured 13.33 mm in length and the head width 1.29 mm on watermelon and 13.34 mm in length and the head width ranged 1.26 mm on pointed gourd. The pupa measured 12.67 mm in length and the head width 1.52 mm on watermelon and 13.69 mm in length and the head width 1.67 mm on pointed gourd. Adult male longevity on watermelon was 6.8 days and 6.2 days on pointed gourd. Adult female longevity on watermelon was 8.6 days and 7.8 days on pointed gourd. The male and female ratio was 1:4 on watermelon, 1:5.6 on pointed gourd. One generation was completed in 33.53 days on watermelon and 30.66 days on pointed gourd.

Post spray observations of larval were recorded with an interval of 24, 48 and 72 hours after spraying. Treatments T₁ (Emamectin benzoate), T₆ (Triazophos) and T₇ (Cartap hydrochloride) showed 100 per cent mortality at 24 hrs after spraying. At 48 hrs of spraying, the treatments T₃ (Dimethoate)

and T₄ (Profenophos) recorded 100 per cent mortality. After 72 hrs spraying treatment T₅ (Azadirachtin) recorded 79.99 per cent mortality and T₂ (Acetamiprid) which showed 76.67 per cent mortality. The treatment T₈ (control) showed no mortality.

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(**Rahul Bharat Rupnar**)

APPENDIX - I

ABBREVIATIONS USED

%	: Per cent
/	: Per
@	: At the rate
>	: Greater than
°C	: Degree Celsius
a. i.	: Active ingredient
C.D at 5%	: Critical difference at 5 per cent
EC	: Emulsifiable concentrate
<i>et al.</i>	: And others
Fig.	: Figure
g	: Gram(s)
DAS	: Days after spraying
Kg	: Kilogram (s)
lit.	: Liter
L ha ⁻¹	: Liter per hectare
mg	: Milligram (s)
ml	: Milliliter (s)
mm	: Millimeter (s)
ppm	: Parts Per Million
C. R. D.	: Completely Randomized Design
R. H.	: Relative Humidity
S. D. ±	: Standard Deviation
S.Em. ±	: Standard error
Tal.	: Taluka
temp.	: Temperature
var.	: Variety
<i>viz.</i> ,	: Namely
NS	: Non-significant

LEGENDS

Tr.No.	Treatment
T1	Emamectin benzoate
T2	Acetamiprid
T3	Dimethoate
T4	Profenophos
T5	Azadirachtin
T6	Triazophos
T7	Cartap hydrochloride
T8(Control)	Water Spray

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*“Dedicated to My beloved
Parents, Farmers and
Agricultural Scientists”*

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CERTIFICATE

This is to certify that the thesis entitled, "BIOLOGY AND EFFICACY OF INSECTICIDES AGAINST PUMPKIN CATERPILLAR, *Diaphania indica* Saunders INFESTING WATERMELON " submitted to the Faculty of Agriculture, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Dist. Ratnagiri, Maharashtra State, in the partial fulfilment of the requirements for the degree of ***MASTER OF SCIENCE (Agriculture)*** in **AGRICULTURAL ENTOMOLOGY**, embodies the results of a piece of bona-fide research carried out by **Mr. RAHUL BHARAT RUPNAR (Reg. No. :ADPM/15/2406)** under my guidance and supervision and that no part of this thesis has been submitted for any other degree or diploma or published in other form. All the assistance and help received during the course of investigation and the sources of literature have been duly acknowledged by him.

Place: Dapoli

Date: 26th May, 2017

(S. K. Mehendale)

Chairman,
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and
Research Guide

**“BIOLOGY AND EFFICACY OF INSECTICIDES AGAINST PUMPKIN
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Diaphania indica Saunders INFESTING WATERMELON”**

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**“BIOLOGY AND EFFICACY OF INSECTICIDES AGAINST PUMPKIN
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Dist. Ratnagiri (Maharashtra State)

In partial fulfillment of the requirements for the degree of

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By

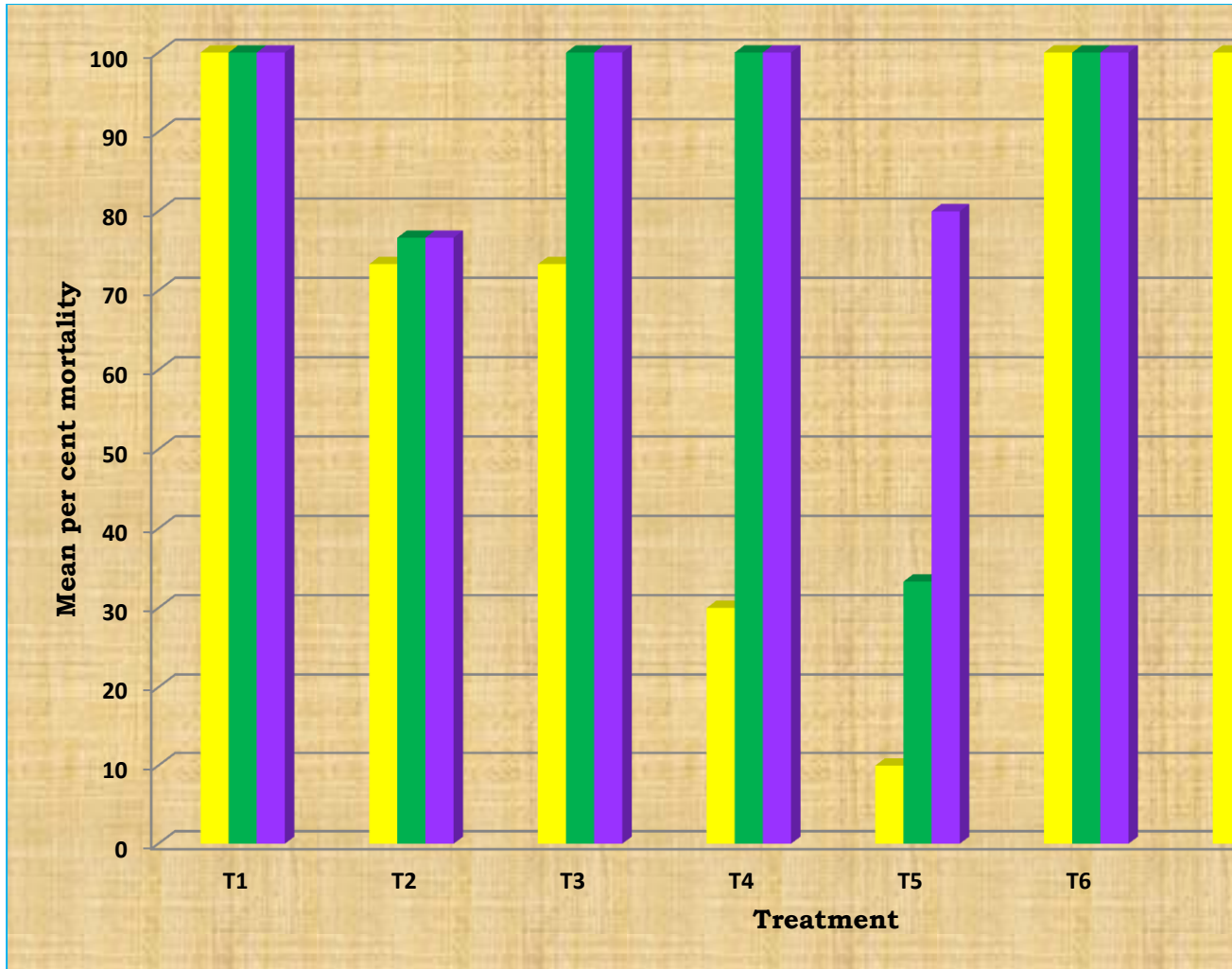
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**Fig. 1. Mean per cent mortality of pumpkin caterpillar, *D. indica*
24, 48 and 72 hours after spraying**



CHAPTER I

INTRODUCTION

Watermelon (*Citrullus lanatus* (Thunb.) Family: Cucurbitaceae) is the major commercial crop in India. Demand for watermelon is getting increased year by year in the Indian market. One who cultivates the watermelon in the month of December, gets an assured profit. The cultivation of watermelon has also brought smiles on the faces of farmers. Its centre of origin has been traced to both the Kalahari and Sahara deserts in Africa (Anonymous, 2014). Watermelon is a warm season crop and can be grown year round in the tropics. It is the most popular summer fruit in India. Watermelons and Indian summer are made for each other. Watermelon is probably the most suitable crop for the summer cultivation. Watermelon is a staple food item in every household during summer days. It is one of the major commercial crop. It is a vegetable like cucumber, squash, pumpkin and cantaloupe, the watermelon really a member of the gourd family. Therefore, horticulturists treat watermelons as to be vegetable's. Worldwide production of watermelon was 95,211,432 MT in 2013. Watermelon produced commercially with the top five countries in the order of decrease in the production are China (72,943 MT), Iran (3,947,057 MT), Turkey (3,887,324 MT), Brazil (2,163,501 MT) and Egypt (1,894,738 MT) (Anonymous 2016). In India, it is commercially grown in tropical and subtropical states. Watermelon is mainly cultivated in Maharashtra, Karnataka, Tamil Nadu, Punjab, Rajasthan, Madhya Pradesh and Uttar Pradesh. In the year 2013, area and production of watermelon in India was 83.58 thousand hectares and 2049.25 thousand MT, respectively. The area under water melon cultivation in Maharashtra region was about 0.33 thousand hectares and Production 5.19 thousand metric tonnes

(Anonymous, 2015a). Cultivation of this crop has been popular now-a-days because of its short duration seeking less labour and high profit. The crop is the major source of income and employment.

Watermelon is attacked by more than a dozen of insect pests, important ones are Red pumpkin beetle; *Raphidopalpafoveicollis* Lucas (Coleoptera: Chrysomelidae), Fruit fly; *Bactrocera cucurbitae* Coquillett (Diptera: Tephritidae), Thrips; *Thrips tabaci* Linderman (Thysanoptera: Thripidae), Whitefly; *Bemisia tabaci* Gennadius (Hemiptera: Aleyrodidae), Aphid; *Aphis gossypii* Glover (Hemiptera: Aphididae), Leaf eating caterpillar; *Diaphania indica* Saunders (Lepidoptera: Pyralidae), Serpentine leaf miner; *Liriomyza trifolii* Burgess (Diptera: Agromyzidae), Red spider mite; *Tetranychus urticae* Koch (Acarina: Tetranychidae).

The cucumber moth, *Diaphania indica* (Saunders), also known as cotton caterpillar or pumpkin caterpillar, is a destructive pest on a widerange of crops. The larvae of *D. indica* attack leaves, flowers and fruit of their hostplants. Preferred hosts for the larvae of this pest are: cucumber, *Cucumis sativus* (L.), gourd, *Lagenaria siceraria* (Standl.), watermelon, *Citrullus lanatus* (Thunb.), oriental melon, *Cucumis melo* var. *makuwa* (Mac.), wax gourd, *Benincasa hispida* (Cogn.), melon, *Cucumis melo* (L.), star cucumber, *Sicyos angulatus* (L.), sponge cucumber, *Luffa cylindrica* (L.), cotton, *Gossypium indicum* (L.), bitter gourd, *Momordica charantia* (L.), littlegourd, *Coccinia indica* (L.) Voigt, and pointed gourd, *Trichosanthes dioica* Roxb., (Tripathi & Pandey, 1973; Pandey, 1977; Clavijo *et al.*, 1995; Raviet *et al.*, 1998; Capinera, 2001; Choi *et al.*, 2003). Cucumber moth, *D. indica* is one of the serious pest of plants under cucurbitaceae. *D. indica* infests cucumber, melon, gherkin, bottle gourd, bitter gourd, snake gourd, Luffa, little cucumber, cotton *etc.* It is reported in other families like Leguminosae and

Malvaceae. The synonyms are *Botythyphalinalis*, *Eudiotiscapensis*, *Glyphodesindica*, *Hedyleptaindica*, *Margaroniaindica*, *Palpitaindica*, *Phacelluraindica*, *Phakelluracurcubitalis*, *Phakelluragazorialis*, *Phakellurazygaenalis*.

D.indica was first reported on cotton leaves from India (Hampson, 1896). Lefroy (1906) recorded this pest on cucurbits in India. Subsequently, Ayyar (1923, 1968) reported *Margaronia* (= *Diaphania*) *indica* as one of the major pests that cause substantial damage to cucurbits. Host record of *D. indica* includes a number of cucurbits (Segeren 1983, Viraktamath *et al.*, 2003). Though *D. indica* often feeds on leaves, its attack on fruits can lead to marketable loss (Ravi, 1998). *Diaphaniaindica* cause serious damage to green-house cucumber and melons (Shimizu, 2000, Kinjo and Arakaki, 2002). The larvae of *D. indica* feed on flowers, leaves and fruits of cucurbits and cause 14 to 30 Percent yield loss in different cucurbit crops (Jhala *et al.*, 2005; Singh and Naik, 2006; Patel and Kulkarny, 1956).

Newly hatched *D.indica* larvae lack color, but are pale yellow green in the second instar stage and mature *D.indica* larvae are of dark green color. Larvae feed on cucurbit foliage and typically remain undersides of leaf. When a population is high, it can devour fruit, leaves, stalks and vines, leaving only stalk material, veins and veinlets of leaves.

D.indica larvae construct a silken structure on the undersides of leaves and continue to develop and feed on foliage. Larva folds the leaves and scrapes the green matter. As a result the leaves get dried up. It can also feed on ovaries of flower; sometimes bore into young developing fruits. Young fruits are also attacked; the caterpillars damage the skin and cause the fruits to rot (Plate 1). Pupation occurs inside a silken cocoon on the plant, often within a folded

section of green leaf material. The larva may feed on the surface of the fruit and cause scars on the surface of melons or even burrow into the fruit.

Watermelon is a short term crop. It gives good earning to farmers within 90 days. Even if it is done in small acreage, a farmer can earn a good profit. Watermelon is becoming a very important source of income for small scale farmers of the semi-arid tropics of West Africa (Fatondji, 2008). In *Konkan* region also, farming practices are carried out on small land holdings. Watermelon cultivation can give good earning and economic stability to the farmers. Farmers can get good profit when their crop gets less infected with pest attack. Nowadays in Maharashtra state, *D.indica* has become a serious problem causing considerable damage to watermelons. The available research work on its effective control is less in Maharashtra and the *Konkan* region in particular. For this purpose, present study was undertaken with the below mentioned objectives.

1. To study Biology of Pumpkin caterpillar, *D. indica* on Watermelon.
2. To study efficacy of insecticides against Pumpkin caterpillar, *D. indica* on Watermelon under laboratory conditions.

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CHAPTER III

MATERIAL AND METHODS

The present investigation entitled, “Biology and efficacy of insecticides against Pumpkin caterpillar, *Diaphainaindica* Saunders infesting watermelon.” was undertaken at Laboratory, Department of Agricultural Entomology, College of Agriculture, Dapoli from November 2015 to March, 2016. Simultaneously biology of Pumpkin caterpillar *D. indica* on watermelon and pointed gourd was carried out. The details of the material used and methodology adopted during the course of investigation are given in this chapter under the following headings.

1. To study Biology of Pumpkin caterpillar *D. indica* on Watermelon and Pointed gourd.
2. To study efficacy of insecticides against Pumpkin caterpillar *D. indica* on Watermelon under laboratory conditions.

3.1 To study Biology of Pumpkin caterpillar *D. indica* on Watermelon and Pointed gourd.

3.1.1 Materials used:

1. Camel hair brush	9. Cotton swab
2. Rubber bands	10. Plastic trays
3. Glass jars(23×11cm)	11. Honey solution
4. Muslin cloth	12. Scissor
5. Small plastic bottles(10×08cm)	15. Acrylic cage
6. Small plastic vials(7×25cm)	16. Plastic pots. (40×30cm)
7. Watermelon and Pointed gourd leaves	17. deno-lite digital microscope
8. Marker Pen	

3.1.2 Maintenance of culture of Pumpkin caterpillar *D. indica*.

The research work comprising studies on biology of Pumpkin caterpillar *D. indica*, its culture was maintained in Laboratory, Department of Agricultural Entomology, College of Agriculture, Dapoli.

To obtain initial culture, pre-pupa and pupa from leaves were collected from farmer field and kept them into small plastic bottles for emergence of adults. The adults thus obtained were released in glass bottles in the laboratory for egg laying. The top of glass jar was covered with muslin cloth secured firmly with a rubber band.

This culture was used for further rearing of Pumpkin caterpillar *D. indica* in laboratory on watermelon and pointed gourd and also used for further biological studies.

3.1.3 Maintenance of host plants (watermelon and pointed gourd):

The research work comprising studies on biology of Pumpkin caterpillar *D. indica*. Unsprayed watermelon and pointed gourd

plants were maintained in plastic pots in Laboratory, Department of Agricultural Entomology, College of Agriculture, Dapoli.

3.1.4 Biology of Pumpkincaterpillar, *D. indica*.

3.1.4.1 Pre-oviposition period

The period required from the emergence of female moth from pupa to the commencement of egg laying was recorded for five females .Average pre-oviposition period was then worked out.

3.1.4.2 Oviposition period

The period during which the female moth laid eggs was recorded for five females. The average oviposition period was worked out.

3.1.4.3 Post-oviposition period

The period from cessation of oviposition by female moth till its death was recorded for five females. On this basis average post oviposition period was worked out.

3.1.4.4 Fecundity

One female and one male adult were released into the glass jar as described above. Total of five such glass jars were kept under observations. Observations on egg laying were made daily. The total numbers of eggs laid on inner surface of glass jar and on muslin cloth by a female during its lifetime were recorded. The mean number of eggs laid by a female' moths were worked out on the basis of total number of eggs laid and data were presented. The measurements of ten eggs were recorded. The average was worked out.

3.1.4.5 Incubation period and hatching percentage:

Randomly ten eggs laid on glass wall were selected by making markings with marker pen. Eggs were observed daily for

hatching. The average incubation period and hatching percentage were worked out from this data and presented.

3.1.4.6 Larval rearing:

Ten newly hatched larvae were transferred to fresh watermelon leaf individually by using a moist camel hair brush and they were kept into 14cm length and 9 cm diameter plastic bottle individually. A piece of blotting paper was provided at its bottom. Fresh healthy leaves were provided daily as food for larvae until pupation. The leftover food and excreta were removed daily.

3.1.4.7 Larval instars:

Larvae were observed for moulting. Larval instar was also noted by changes in head width with the help of deno-lite digital microscope. The duration of larval instars were recorded. The linear measurements on head width, body length were recorded by using deno-lite digital microscope. The data thus obtained were averaged out and presented.

3.1.4.8 Prepupal period:

The period required from initiation of construction of cocoon by larva to complete formation of pupa was recorded for ten larvae. The data thus obtained were averaged out and presented. The average length and breadth of prepupae were worked out.

3.1.4.9 Pupal period:

Ten pupae were kept in 23cm length and 11cm diameter glass jar; the top of which covered with muslin cloth secured firmly with a rubber band. The period from attendance of pupal stage to the emergence of adults, was considered as pupal period and

observations regarding pupal period were taken. The average length and breadth of pupa was worked out.

3.1.4.10 Adult longevity:

Newly emerged adults from the culture were separated for their sexes and kept in 41cm length and 30cm diameter glass jar; the top of which was covered with muslin cloth secured firmly with a rubber band. The cotton swab soaked in ten percent solution was kept suspended in the glass jar with the help of thread which served as a food for adults. A total of ten adults were observed. The longevity of ten males and females were recorded by observing the duration between emergences to the death of adult. The data thus obtained were used to calculate average longevity of male and female along with the host plant.

3.1.4.11 Sex ratio

To determine sex ratio, ten pupae obtained from the egg laying of a female were kept under observation individually in a plastic vial. The adults emerged from them were observed according to their sexes and sex ratio was worked out.

3.1.4.12 Life cycle

The total period for the completion of life cycle was worked out based on the duration of egg, maggot, pre-pupal, pupal and adult stages.

3.2 To study the efficacy of insecticides against Pumpkin caterpillar *D. indica* on Watermelon under laboratory conditions.

A laboratory experiment was conducted in the Department of Agricultural Entomology, College of Agriculture, Dapoli from November 2015 to March, 2016 to study the effectiveness of some insecticides against Pumpkin caterpillar *D. indica*. The details of

insecticides with desired concentrations as per treatment details are given in Table 1.

3.2.1 Materials used to study the efficacy of insecticides against Pumpkin caterpillar *D. indica* on Watermelon under laboratory conditions.

1. Camel hair brush	2.Filter paper
3.Small plastic bottles	4.Hand sprayer
5.Cotton swab	6.Insecticides
7.Glass jar	8.Glass Petri Dishes
9. Scissor	

3.2.2 Experimental details:

A laboratory experiment was conducted in Completely Randomized Design (CRD), with three replications and eight treatments were laid out at Department of Agricultural entomology, College of Agriculture, Dapoli.

Design : Completely Randomized Design (CRD)

Replications : 3

Number of treatments : 8

Table 1; Treatment details:

Sr. No.	Insecticides	%Conc.	Dose
T1	Emamectin benzoate	0.0015%	0.3g/l
T2	Acetamiprid	0.002%	0.1g/l
T3	Dimethoate	0.03%	1ml/l
T4	Profenophos	0.075%	1.5 ml/l
T5	Azadirachtin	0.003%	3ml/l
T6	Triazophos	0.08%	2ml/l

T7	Cartap hydrochloride	0.075%	1.5g/l
T8(Control)	Water Spray	-	-

3.2.3Method of application:

Fresh leaves of watermelon were collected from potted plants and sprayed with the different insecticidal solutions of mentioned concentration. Then these leaves were thoroughly air dried. These leaves were placed in separate petri dish individually. Then ten larvae of third instar of pumpkin caterpillar were released in each petri plate.

3.2.3Method of recording mortality observation of *D. indica*:

Observations were recorded each after 24, 48 and 72 hrs regarding the mortality of larvae in different insecticidal treatments. Data thus collected was statistically analyzed to judge the effective insecticide.

Table 2: Details of insecticides used against Pumpkin caterpillar, *D. indica*

Sr . No .	Common name	Trade name	Formulation	Concentration Used/Dose	Source
1	Dimethoate	Tafgor®	30% EC	0.003 %	M/s. Tata Rallies India Limited, NarimanBhavan, 15 th floor, 227 Nariman point, Mumbai-400 021
2	Profenofos	Curacron®	50% EC	0.075 %	M/s. Syngenta India Limited, Amar Paradigm, S. No. 110/11/3, Baner Road, Pune- 411 045, M. S.
3	Emamectin benzoate	Proclaim®	5 SG	0.0015 %	M/s. Syngenta India Limited, Amar Paradigm, S. No. 256/15/3, Baner Road, Pune- 411 045, M. S.
4	Acetamiprid	Manik®	20 SP	0.002 %	M/s. Tata Rallies India Limited, NarimanBhavan, 15 th floor, 227 Nariman point, Mumbai-400 021
5	Azadirectin	Econee m®	10000ppm	0.003 %	M/s. Margo Private Limited, #3A, Antharasanah

					ally industrial Area, Tumakur-572 106. Karnataka
6	Cartap Hydrochloride	Caldan [®]	50% SP	0.075 %	M/s. Dhanuka Agritech Limited, D1/A-B, Ajanta Industrial Estate, Sanand, Ahmedabad-382 170
7	Triazophos	Triazoce 1 [®]	40% EC	0.08 %	M/s. Excel Crop Care Limited, S. V. Road, Jogeshwari (west), Mumbai-400 102, Maharashtra.
8	Untreated control	-	-	-	-



Plate 1: Damage caused by *D. indica* to Watermelon
fruits



Plate 2: Dino-lite Digital microscope



Plate 3: Maintenance of culture of *D. indica*



Plate 4: Individual rearing of *D. indica* larva in Plastic bottles



Plate 5: Efficacy of insecticides against Pumpkin caterpillar *D. indica* on Watermelon



Plate 6: Egg of *D. indica*



Plate 7A: First Instar Larva of *D. indica*



Plate 7B: Second Instar Larva of *D. indica*



Plate 8A: Third Instar Larva of *D. indica*



Plate 8B: Fourth Instar Larva of *D. indica*



Plate 9: Fifth Instar Larva of *D. indica*



Plate 10A: Pre-pupa of *D. indica*



Plate 10B: Pre-pupa of *D. indica*



Plate 11A: Male of *D. indica*



Plate 11B: female of *D. indica*



CHAPTER IV

RESULTS AND DISCUSSION

The present investigation entitled, "Biology and efficacy of insecticides against pumpkin caterpillar, *Diaphaina indica* Saunders infesting watermelon." was undertaken at Department of Agricultural Entomology, Dapoli. The results obtained during the study are presented and discussed under the following headings.

4.1 Biology of Pumpkin caterpillar, *D. indica*:

The biology of *D. indica* was studied in the laboratory of the Department of Agricultural Entomology, College of Agriculture, Dapoli, Dist. Ratnagiri from November 2015 to March, 2016. The observations of morphometrics are taken with dino lite digital microscope (Plate 2). The results obtained are presented and discussed hereunder.

4.1.2 Site of oviposition

The female usually laid eggs singly or in clusters of two or more during night time mostly on tender leaves, stalks and vines in the field, however, eggs were also observed on the glass jar and muslin cloth. The results are in conformity with the findings of the Ganeshachari (1997) who reported that eggs *D. indica* were laid singly or in small clusters on the lower surface of snake gourd leaves while Korgaonkar (1999) also reported that eggs were noticed on leaves and muslin cloth.

4.1.3 Eggs

The freshly laid eggs were white to yellowish in colour and elongated in shape (Plate 6). The eggs measured 0.85 to 0.95 mm in length with an average of 0.87 mm and 0.54 to 0.58 mm in

breath with an average of 0.57 mm (Table 3).At the hatching egg became orange in color.The results are in conformity with the findings of the Barma and Jha (2014) who reported that freshly laid eggs were very small, and yellow in color, measured from 0.73to 0.95mm in length and 0.30 to 0.45 mm in breadth.

Table 3: Morphometrics of Egg stage of *Diaphania indica*(Saund.)

Sr.No.	Egg Length(mm)	Egg Breadth(mm)
1	0.852	0.542
2	0.866	0.574
3	0.878	0.587
4	0.950	0.589
5	0.892	0.563
6	0.872	0.581
7	0.883	0.569
8	0.859	0.584
9	0.861	0.576
10	0.874	0.578
Range	0.852-0.950	0.542-589
Mean	0.89	0.574
S.D. $\pm$	0.028	0.014

4.1.4 Pre-oviposition, oviposition and post-oviposition period:

The pre-oviposition, oviposition and post-oviposition period were recorded and the results are presented in Table 2. It was revealed that the pre-oviposition period varied from 2to 3 days with an average of 2.2 days. The oviposition period ranged

between 4 to 5 days with an average 4.4 days. The post-oviposition period was recorded only for 1 to 2 days with a mean of 1.6 days. These observations are in close conformity with the findings of the Korgaonkar (1999) who reported that the pre-oviposition, oviposition and post-oviposition period of 2, 5.1 and 1.5 days, respectively on pointed gourd.

4.1.5 Fecundity

The data recorded on fecundity of Pumpkin caterpillar, *D. indica* revealed that the total number of eggs laid by female in her life span varied from 116 to 308 with an average of 193.4 (Table 4). The observations are in accordance with Korgaonkar (1999) who reported that the female of *D. indica* laid 93 to 306 eggs with an average of 187.1.

Table 4: Pre-oviposition, oviposition and post-oviposition period of *Diaphania indica*

Female No.	Pre-oviposition period (days)	Oviposition period(days)	Post-oviposition period (days)	Fecundity
1	2	4	2	178
2	2	4	2	192
3	2	4	2	308
4	2	5	1	116
5	3	5	1	173
Range	2-3	4-5	1-2	116-308
Mean	2.2	4.4	1.6	193.4
S.D. $\pm$	0.4472	0.548	0.548	70.32

4.1.6 Incubation period and hatching percentage

The data on incubation period and hatching percentage are presented in Table 3. It was evident from the data that the incubation period ranged from 4 to 4.5 days with a mean of 4.3days. Hatching percentage ranged from 100 per cent with an average of 100 per cent (Table 5). Similar observations were recorded by Barma and Jha (2014), they recorded incubation period was 3.7days at 30 °C and Korgaonkar (1999) reported that incubation period ranged from 4 to 6 days with a mean of 4.75 days with 90.4 per cent hatching.

Table5: Incubation period and Hatching percentage

Sr.No.	No. of eggs observed	No. of eggs hatched(days)				Total eggs hatched	Incubation period	Per cent eggs hatched
		2	3	4	5			
1	10	–	–	8	2	10	4.5	100
2	10	–	1	8	1	10	4	100
3	10	–	–	8	2	10	4.5	100
4	10	–	–	9	1	10	4.5	100
5	10	–	1	6	3	10	4	100
6	10	–	–	8	2	10	4.5	100
7	10	–	1	8	1	10	4	100
8	10	–	–	7	3	10	4.5	100
9	10	–	–	8	2	10	4.5	100
10	10	–	1	7	2	10	4	100
Range	10					10	4-4.5	100

Mean	10		1	7.7	1.9	10	4.3	100
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4.1.7 Larval development

During present studies, larval and subsequent stages of *D. indica* were comparatively studied on Watermelon and Pointed gourd and data are presented. It was observed that there were five larval instars. The observations on larval instars and larval period are given in Table 6. The development period of larvae on watermelon was 13 days with an average of 13 days. The development period of larvae on pointed gourd was 11 days with an average of 11 days. During this period larvae moulted four times.

Table 6: Development period of larva

Duration of larval instars (days) on watermelon							Duration of larval instars (days) on Pointed gourd						
Sr. No.	I	II	III	I V	V	Total larval period (days)	Sr. No.	I	II	III	IV	V	Total larval period (days)
1	2	3	2	3	3	13	1	2	2	2	2	3	11
2	2	3	2	3	3	13	2	2	2	2	2	3	11
3	2	3	2	3	3	13	3	2	2	2	2	3	11
4	2	3	2	3	3	13	4	2	2	2	2	3	11
5	2	3	2	3	3	13	5	2	2	2	2	3	11
Range	2	3	2	3	3	13	Range	2	2	2	2	3	11
Mean	2	3	2	3	3	13	Mean	2	2	2	2	3	11

The present observations are in close conformity with Barma and Jha (2014), who recorded larval period of 7 to 11

days with an average of 9.5 at 30°C. Korgaonkar (1999) reported that the larval development was completed from 10 to 14 days with an average of 11.90 days.

4.1.7 A: First instar

The first instar lasted for 2 days with mean of 2 days on both watermelon and pointed gourd (Table 6). Newly hatched larva was tiny, active and creamy white. Larva was polypod, slender and had a black spot on each side of the head and dark brown tubercles on each body segment which occurred in transverse rows. Head was wider than body (Plate 7A). Larva measured 1.0 to 1.2 mm in length with an average of 1.1 mm and 0.12 to 0.14 mm in head width with an average of 0.13 mm on watermelon and 1.8 to 1.99 mm in length with an average of 1.93 mm and 0.20 to 0.24 mm in head width with an average 0.23 mm on pointed gourd (Table 7).

Table 7: Morphometrics of first instar larvae of *D. indica*

Sr. No.	on watermelon		On pointed gourd	
	Body length (mm)	Head width (mm)	Body length (mm)	Head width (mm)
1	1.2	0.14	1.83	0.24
2	1.0	0.12	1.97	0.20
3	1.2	0.14	1.90	0.24
4	1.0	0.13	1.99	0.23
5	1.0	0.13	1.95	0.23
Range	1.0-1.2	0.12-0.14	1.8-1.99	0.20-0.24
Mean	1.1	0.13	1.93	0.23
S.D.±	0.11	0.01	0.06	0.01

The present observations are in close conformity with Korgaonkar (1999) who reported 0.187 to 0.262 mm of head capsule width with an average of 0.230 mm and length of larvae 1.650 to 2.250 mm with an average of 1.893 mm on pointed gourd.

4.1.7 B: Second instar:

The second instar lasted for 3 days with mean of 3 days on watermelon and 2 days with mean of 2 days on pointed gourd. (Table 6). Larva was yellowish green. Head hypognathous, smaller in size than rest of body. There were nine pairs of spiracles, the first on prothoracic segment and remaining eight on each of abdominal segment. Prolegs fleshy and yellowish. Abdomen ten segmented. The fifth, sixth, and tenth segment had prolegs (Plate 7B). Larva measured 3.97 to 4.96 mm in length with an average of 4.63 mm and 0.28 to 0.37 mm in head width with an average of 0.33 mm on watermelon and 3.92 to 4.38 mm in length with an average of 4.17 mm and 0.36 to 0.39 mm in head width with an average 0.38 mm of on pointed gourd (Table 8).

Table 8: Morphometrics of second instar larvae of *D.indica*

Sr. No.	on watermelon		On pointed gourd	
	Body length (mm)	Head width (mm)	Body length (mm)	Head width (mm)
1	4.96	0.31	4.32	0.37
2	4.84	0.36	4.38	0.38
3	4.90	0.28	4.19	0.38
4	4.50	0.33	4.03	0.36
5	3.97	0.37	3.92	0.39

Range	3.97-4.96	0.28-0.37	3.92-4.38	0.36-0.39
Mean	4.63	0.33	4.17	0.38
S.D.±	0.41	0.03	0.19	0.01

The present observations are in close conformity with Korgaonkar (1999) who reported 0.37 to 0.45 mm of head capsule width with an average of 0.39 mm and length of larvae 2.925 to 3.187 mm with an average of 3.20 mm on pointed gourd.

4.1.7 C: Third instar:

The third instar lasted for 2 days with mean of 2 days on both watermelon and on pointed gourd (Table 6). Larva was yellowish green. A row of black tubercles bearing setae were seen on thoracic and abdominal segment (Plate 8A). Larva measured 6.90 to 7.49 mm in length with an average of 7.22 mm and 0.55-0.61 mm in head width with an average of 0.59 mm on watermelon and 6.42 to 7.82 mm in length with an average of 7.23 mm and 0.44 to 0.57 mm in head width with an average 0.50 mm of on pointed gourd (Table 9).

Table 9: Morphometrics of third instar larvae of *D. indica*

Sr. No.	on watermelon		On pointed gourd	
	Body length (mm)	Head breadth (mm)	Body length (mm)	Head breadth (mm)
1	7.41	0.60	7.44	0.57
2	7.29	0.59	7.82	0.53
3	6.99	0.59	6.42	0.50
4	6.90	0.55	7.22	0.44
5	7.49	0.61	7.24	0.48
Range	6.90-7.49	0.55-0.61	6.42-7.82	0.44-0.57

Mean	7.22	0.59	7.23	0.50
S.D.±	0.25	0.02	0.51	0.48

The present observations are in close conformity with Korgaonkar (1999) who reported 0.600 to 0.712 mm of head capsule width with an average of 0.648 mm and length of larvae 5.50 to 7.00 mm with an average of 6.30 mm on pointed gourd.

4.1.7 D: Fourth instar:

The fourth instar lasted for 3 days with mean of 3 days on watermelon and 2 days with mean of 2 days on pointed gourd (Table 6). Larva was green, head hypognathous, smaller in size than rest of body (Plate 8B). Larva measured 10.31 to 11.35 mm in length with an average of 11.00 mm and 0.88 to 1.08 mm in head width with an average of 0.97 mm on watermelon and 10.76 to 12.85 mm in length with an average of 11.66 mm and 0.81 to 0.88 mm in head width with an average 0.84 mm of on pointed gourd (Table 10).

Table 10: Morphometrics of fourth instar larvae of *D.indica*

Sr.No.	on watermelon		On pointed gourd	
	Body length (mm)	Head width (mm)	Body length (mm)	Head width (mm)
1	11.35	0.88	12.49	0.81
2	11.02	0.91	12.85	0.88
3	10.31	0.98	10.83	0.82
4	11.10	1.08	10.76	0.86
5	11.25	1.00	11.35	0.85
Range	10.31-11.35	0.88-1.08	10.76-12.85	0.81-0.88
Mean	11.00	0.97	11.66	0.84

S.D.±	0.41	0.07	0.96	0.02
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The present observations are in close conformity with Korgaonkar (1999) who reported 0.900 to 1.087 mm of head capsule width with an average of 0.987 mm and length of larvae 10.00 to 12.00 mm with an average of 11.12 mm on pointed gourd.

4.1.7 E: Fifth instar:

The fifth instar lasted for 3 days with mean of 3 days on both watermelon and on pointed gourd (Table 6). Larva was green with whitish head. A row of black tubercles bearing setae were seen on thoracic and abdominal segment (Plate 9). Larva measured 14.10 to 16.91 mm in length with an average of 15.92 mm and 1.55 to 1.71 mm in head width with an average of 1.63 mm on watermelon and 16.08 to 14.86 mm in length with an average of 15.47 mm and 1.23 to 1.48 mm in head width with an average 1.36 mm of on pointed gourd (Table 11)

Table 11: Morphometrics of fifth instar larvae of *D.indica*

Sr. No.	On watermelon		On pointed gourd	
	Body length (mm)	Head width (mm)	Body length (mm)	Head width (mm)
1	16.91	1.71	16.08	1.39
2	15.73	1.56	14.86	1.48
3	14.10	1.55	15.59	1.42
4	16.04	1.63	15.63	1.23
5	16.81	1.71	15.16	1.28
Range	14.10-16.91	1.55-1.71	16.08-14.86	1.23-1.48
Mean	15.92	1.63	15.47	1.36
S.D.±	1.13	0.07	0.47	0.10

The present observations are in close conformity with Korgaonkar (1999) who reported 1.537 to 1.725 mm of head capsule width with an average of 1.625 mm and length of larvae 20.00 to 23.00 mm with an average of 21.85 mm on pointed gourd. Also the results are in conformity with the findings of the Barma and Jha (2014) who reported that length of larvae was 17.20 to 18.50 mm with an average of 18.04 mm and head width was 3.01 to 3.36 mm with an average of 3.21 mm.

4.1.8: Pupation

The observations on the development period of prepupa and pupa are presented in Table 10.

4.1.8A: Prepupal period:

The full grown larva before pupation passed through a prepupal stage, it stopped feeding, became sluggish, gradually shrunk in length and started preparing a thin silken web around the body on the lower surface of leaf. After spinning the cocoon, it remained quiescent for one or two days. During this period, feeding was arrested. The larva turned pale green and gradually shortened to the size of a future pupa. Then larva passed through a moult inside the cocoon (Plate 10A). Prepupal period lasted for 2.08 to 2.25 days with an average of 2.17 days on watermelon and 2.08 to 2.16 days with an average of 2.12 days on pointed gourd (Table 12).

4.1.8B: Pupal period:

Under laboratory conditions pupation took place on the under surface of leaf. It was also noticed that the larva also pupated on the blotting paper. The freshly formed pupa was

greenish, gradually turned shiny reddish brown and finally became dark brown prior to the emergence of adult. Pupa was abtect with cylindrical body. The anterior end of pupa was somewhat blunt; the posterior end was pointed and bears several spines which had curved tips that hold the pupa in its thin cocoon(Plate 10B). The pupal period lasted for 6.03 to 7.21 days with an average of 6.714 days on watermelon and 6.02 to 6.57 days with an average of 6.194days on pointed gourd(Table12).

Table12: Pre pupal and Pupalperiod (days)

Sr.No.	Development period(days) on watermelon		Development period(days) on Pointed gourd	
	Pre pupa	Pupa	Pre pupa	Pupa
1	2.25	7.02	2.12	6.02
2	2.14	6.87	2.10	6.57
3	2.08	6.03	2.08	6.03
4	2.20	7.21	2.16	6.22
5	2.21	6.44	2.14	6.13
Range	2.08-2.25	6.03-7.21	2.08-2.16	6.02-6.57
Mean	2.17	6.71	2.12	6.19
S.D.±	0.06	0.47	0.03	0.22

The present observations are in close conformity withKorgaonkar (1999) who reported pre pupal period lasted for 1 to 2 days with an average of 1.3 days and pupal period lasted

for 8 to 11 days with an average of 9.4 days. The results are also in conformity with the findings of the Barma and Jha (2014) who reported pre pupal period lasted for 1 to 3 days with an average of 1.9 days and pupal period lasted for 7 to 11 days with an average of 8.9 days at 30°C.

4.1.8C: Morphometrics of pre pupae:

The pre pupa measured from 13.28 to 13.36 mm in length with an average of 13.33 mm and the head width ranged from 1.25 to 1.32 mm with an average of 1.29 mm on watermelon and 13.25 to 13.53 mm in length with an average of 13.34 mm and the head width ranged from 1.22 to 1.31 mm with an average of 1.26 mm on pointed gourd (Table 13). The present observations are less or more in conformity with Korgaonkar (1999) who reported pre pupal length varied from 19.00 to 21.00 mm with an average of 19.95 mm and width varied from 2.50 to 3.00 mm with an average of 2.77 mm.

Table 13: Morphometrics of pre pupa of *D.indica*

Sr. No.	On watermelon		On pointed gourd	
	Body length (mm)	Head width (mm)	Body length (mm)	Head width (mm)
1	13.33	1.25	13.27	1.25
2	13.28	1.32	13.25	1.23
3	13.30	1.31	13.50	1.31
4	13.36	1.26	13.53	1.22
5	13.35	1.29	13.43	1.24
Range	13.28-13.36	1.25-1.32	13.25-13.53	1.22-1.31
Mean	13.33	1.29	13.34	1.26
S.D.±	0.03	0.02	0.13	0.03

4.1.8 D:Morphometrics of pupae:

The pupa measured from 12.15 to 13.11 mm in length with an average of 12.67 mm and the head width ranged from 1.44 to 1.64mm with an average of 1.52 mm on watermelon and 13.25 to 13.85 mm in length with an average of 13.69mm and the head width ranged from 1.59 to 1.70mm with an average of 1.67 mm on pointed gourd (Table 12). The present observations are less or more in conformity with Korgaonkar (1999) who reported pupal length varied from 12.00 to 14.00 mm with an average of 13.00 mm and width varied from 2.50 to 3.00 mm with an average of 2.75mm. The results are also in conformity with the findings of the Barma and Jha (2014) who reported pupal length varied from 13.00 to 14.20 mm with an average of 13.63 mm and width varied from 2.54 to 3.03 mm with an average of 2.83mm.

Table 14: Morphometrics of pupa of *D.indica* on watermelon

Sr. No.	on watermelon		On pointed gourd	
	Body length (mm)	Head width (mm)	Body length (mm)	Head width (mm)
1	12.98	1.60	13.74	1.59
2	12.62	1.49	13.85	1.70
3	13.11	1.45	13.83	1.69
4	12.52	1.64	13.78	1.68
5	12.15	1.44	13.25	1.68
Range	12.15-13.11	1.44-1.64	13.25-13.85	1.59-1.70
Mean	12.67	1.52	13.69	1.67
S.D.±	0.3814	0.09025	0.247	0.0460

4.1.9: Adult longevity:

The adult longevity was studied in laboratory for both the sexes and for the both hosts from which adults were emerged out. After emergence, the expansions of wings were completed in about ten minutes and moth was ready to fly within fifteen

minutes. Moths had a brush like tuft of yellowish orange coloured hairs at their anal end. The brush was smaller in case of male. In male; there was a black dot in the centre of yellowish orange brush dorsally. This dot was absent in case of female. In female, there was a receiving organ at the centre of yellowish orange brush ventrally. Female abdomen was relatively bigger in size and broad as compared to male. The moths frequently can be seen holding their brushes above the body leveled slowly waving them in a circular fashion. Adult male longevity on watermelon was 6 to 7 days with an average of 6.8 days and 6 to 7 days with an average of 6.2 days on pointed gourd. Adult female longevity on watermelon was 8 to 9 days with an average of 8.6 days and 7 to 8 days with an average of 7.8 days on pointed gourd (Table 15).

Table 15: Adult longevity

Sr.No.	Adult longevity on watermelon(days)		Adult longevity on pointed gourd(days)	
	Male	Female	Male	Female
1	7	8	6	8
2	7	9	6	8
3	6	8	6	8
4	7	9	6	7
5	7	9	7	8
Range	6-7	8-9	6-7	7-8
Mean	6.8	8.6	6.2	7.8
S.D.±	0.44	0.54	0.44	0.44

The present observations are in close conformity with Korgaonkar (1999) who reported longevity of female moth varied from 7 to 10 days with an average of 8.45 days and

longevity of male moth varied from 8 to 11 days with an average of 9 days. The results are also in conformity with the findings of the Barma and Jha (2014) who reported adult longevity varied from 8 to 11 days with an average of 9.5 days at 30°C.

4.1.9.1: Morphometrics of Adults:

A: Female adult

Moth medium sized, stoutly built with white wings which have an iridescent purplish reflection and brownish border. At rest the wings held like a flat over the body. Wing expansion ranged from 22.95 to 23.90 mm with an average of 23.58 mm on watermelon and from 22.78 to 23.14 mm with an average of 22.94 mm on pointed gourd. Head small, hypognathous and brown. Compound eyes were reddish and prominent. Antenna was filiform with numerous segments. Mouth parts well developed with a long and coiled proboscis (Plate 11B). Head width ranged from 1.90 to 2.10 mm with an average 2.10 mm of on watermelon and 1.91 to 2.15 mm on with an average of 1.99 mm on pointed gourd. Body width ranged from 3.07 to 3.38 mm with an average of 3.23 mm on watermelon and 2.89 to 3.10 mm on with an average of 2.974 mm on pointed gourd. Legs slender, pale white. Abdomen elongated, conical, eight segmented, tapering posteriorly having a yellowish orange brush at the anal end. Abdomen was relatively bigger in size and broad as compared to male moth. The body length ranged from 12.31 to 12.90 mm with an average of 12.49 mm on watermelon and from 11.88 to 12.16 mm with an average of 11.98 mm on pointed gourd (Table 16).

Table 16: Morphometrics of adult female of *Diaphania indica*

on watermelon	On pointed gourd

Sr.No	Head width (mm)	Body width (mm)	Body length (mm)	Wing span (mm)	Head width (mm)	Body width (mm)	Body length (mm)	Wing span (mm)
1	2.07	3.25	12.45	23.90	1.97	3.00	12.00	22.78
2	2.10	3.07	12.31	23.68	1.91	2.97	11.88	22.89
3	1.98	3.38	12.40	22.95	2.00	2.91	11.93	23.14
4	1.90	3.19	12.39	23.60	2.15	3.10	12.16	22.91
5	2.00	3.30	12.90	23.78	1.96	2.89	11.92	22.97
Range	1.90-2.10	3.07-3.38	12.31-12.90	22.95-23.90	1.91-2.15	2.89-3.10	11.88-12.16	22.78-23.14
Mean	2.01	3.23	12.49	23.58	1.998	2.974	11.98	22.94
S.D.±	0.07	0.11	0.23	0.37	0.09	0.08	0.11	0.13

The present observations are in close conformity with Korgaonkar (1999) who reported Wing expanse ranged from 24.00 to 26.00 mm with an average of 25.20 mm, Head width ranged from 1.50 to 2.50 mm with an average 1.95, body width ranged from 2.50 to 3.00 mm with an average of 2.75 mm, the body length ranged from 13.00 to 14.00mm with an average of 13.52 mm.

B: Male adult

Moth medium sized, stoutly built with white wings which have an iridescent purplish reflection and brownish border. At rest the wings held like a flat over the body. Wing expansion ranged from 21.98 to 22.94mm with an average of 22.39mm on watermelon and from 21.84 to 22.21 mm with an average of 22.06 mm on pointed gourd .Head small, hypognathous and brown. Compound eyes were reddish and large. Antenna was filliform with numerous segments. Mouth parts well developed with a long and coiled proboscis(Plate 11B). Head width ranged

from 1.90 to 2.23mm with an average 2.06 mm of on watermelon and 1.89 to 2.26 mm on with an average of 2.044 mm on pointed gourd. Body width ranged from 2.57 to 2.96mm with an average of 2.70 mm on watermelon and 2.38 to 2.66 mm on with an average of 2.49 mm on pointed gourd. Legs slender, pale white. Abdomen elongated, conical, eight segmented, tapering posteriorly having a yellowish orange brush at the anal end. Abdomen was relatively smaller in size and longer as compared to female moth. The body length ranged from 13.19 to 14.10 mm with an average of 13.7 mm on water melon and from 12.73 to 13.21 mm with an average of 12.98mm on pointed gourd (Table 17).

Table 17: Morphometrics of adult Male of *Diaphania indica*

Sr.No	on watermelon				On pointed gourd			
	Head width (mm)	Body width (mm)	Body length (mm)	Wing span (mm)	Head width (mm)	Body width (mm)	Body length (mm)	Wing span (mm)
1	1.90	2.57	13.19	22.94	1.89	2.39	12.98	22.21
2	2.07	2.62	13.42	22.89	1.97	2.44	12.73	21.84
3	2.23	2.78	13.78	21.98	2.16	2.58	13.08	21.97
4	2.10	2.96	14.00	22.16	2.26	2.66	13.21	22.17
5	2.00	2.60	14.10	22.00	1.94	2.38	12.89	22.13
Range	1.90-2.23	2.57-2.96	13.19-14.10	21.98-22.94	1.89-2.26	2.38-2.66	12.73-13.21	21.84-22.21
Mean	2.06	2.70	13.7	22.39	2.044	2.49	12.98	22.06
S.D.±	0.12	0.16	0.38	0.48	0.15	0.12	0.18	0.155

The present observations are in close conformity with Korgaonkar (1999) who reported Wing expanse ranged from 23.00 to 25.00 mm with an average of 24.150 mm, Head width ranged from 1.50 to 2.50 mm with an average 1.875, . Body width ranged from 2.50 to 3.00 mm with an average of 2.675, the body length ranged from 13.00 to 15.00mm with an average of 13.97mm.

4.1.10 Sex ratio

The sex ratio was worked out by examining 20 pupae. Out of 20 pupae examined, 4 were observed to be males and 16 were females after emergence from watermelon and Out of 20 pupae examined, 3 were observed to be males and 17 were females after emergence from pointed gourd. The male and female ratio was 1:4 on watermelon, 1:5.6 on pointed gourd.

4.1.11: Life cycle

Result revealed that egg period varied from 4 to 4.5 days, (mean 4.25 days), larval period was 13 days with an average of 13 days on watermelon and 11 days with an average of 11 days on pointed gourd. Prepupal period was varied from 2.08 days to 2.25 days with an average of 2.16 days on watermelon, 2.08 days to 2.16 days with an average of 2.12 days on pointed gourd. Pupal period was varied from 6.03 days to 7.21 days with an average of 6.62 days on watermelon, 6.02 days to 6.57 days with an average of 6.29 days on pointed gourd. Adult stages varied from 6.00 to 9.00 days with an average of 7.5 days on watermelon, 6.00 days to 8.00 days with an average of 7 days on pointed gourd. One generation was completed in 31.11 to 35.96 days with an average of 33.53 days on watermelon and 29.1 to 32.23 days

with an average of 30.66 days on pointed gourd(Plate 12)(Table 18).

Table 18: Life cycle

Stage	Duration(days) on watermelon			Duration(days) on pointed gourd		
	Min	Max	Mean	Min	Max	Mean
Egg	4	4.5	4.25	4	4.5	4.25
Larval instars						
First	2	2	2	2	2	2
Second	3	3	3	2	2	2
Third	2	2	2	2	2	2
Fourth	3	3	3	2	2	2
Fifth	3	3	3	3	3	3
Total larval period	13	13	13	11	11	11
Pre pupa	2.08	2.25	2.16	2.08	2.16	2.12
Pupa	6.03	7.21	6.62	6.02	6.57	6.29
Adult	6.00	9.00	7.5	6	8	7
Life cycle	31.11	35.96	33.53	29.1	32.23	30.66

The present observations are in close conformity with Korgaonkar (1999) who reported one generation was completed in 31 to 44 days with an average of 36.075 days.

4.2:To Know the efficacy of insecticides against Pumpkin caterpillar,*D. indica* on Watermelon under laboratory conditions:

A laboratory experiment was conducted at the Department of Agricultural Entomology, College of Agriculture, Dapoli from November 2015 to March, 2016 to study the effectiveness of

some insecticides against pumpkin caterpillar, *D. indica* on Watermelon. The data pertaining to the relative efficacy of different insecticides against pumpkin caterpillar are presented in Table. Post spray observations of larval mortality were recorded with an interval of 24, 48 and 72 hours after spraying. The results of the insecticides spraying are discussed below. The results on relative efficacy of insecticides revealed that the treatments T₁(Emamectin benzoate), T₆(Triazophos) and T₇(Cartap hydrochloride) showed 100 per cent mortality at 24 hrs after spraying and all these treatments were at par with each other. The next best treatment were T₂ (Acetamiprid) and T₃ (Dimethoate) which recorded 73.33 per cent mortality. No mortality was recorded in T₈ (Control).

Table 19: Efficacy of insecticides against Pumpkin caterpillar, *D. indica* on Watermelon under laboratory conditions:

Treat.	24 hrs	48 hrs	72 hrs
T1	100.00 (89.19)	100.00 (89.19)	100.00 (89.19)
T2	73.33 (59.00)	76.67 (61.71)	76.67 (61.71)
T3	73.33 (59.00)	100 (89.19)	100.00 (89.19)
T4	30.00	100	100.00

	(32.30)	(89.19)	(89.19)
T5	10.00 (18.43)	33.33 (35.22)	79.99 (67.59)
T6	100.00 (89.19)	100.00 (89.19)	100.00 (89.19)
T7	100.00 (89.19)	100.00 (89.19)	100.00 (89.19)
T8	0.00 (0.91)	0.00 (0.91)	0.00 (0.91)
SEm	2.69	1.88	4.20
CD at 5%	8.52	5.64	12.60

At 48 hrs of spraying, the treatments T3 (Dimethoate) and T4 (Profenophos) recorded 100 per cent mortality and both these treatments were at par with each other whereas the treatments *viz.*, T₁(Emamectin benzoate), T₆(Triazophos) and T₇(Cartap hydrochloride) which already recorded 100 percent mortality at 24 hrs of spraying. The next best treatment was T₂ (Acetamaprid) which showed 76.67 per cent mortality whereas no mortality was recorded in T8 (Control).

Data on relative efficacy of insecticides after 72 hrs spraying revealed that the treatment T5 (Azadirachtin) recorded 79.99 per cent mortality and which was found to be at par with treatment T₂ (Acetamiprid) which showed 76.67 per cent mortality. The treatment T₈ (control) showed no mortality. The treatments *viz.*, T₁ (Emamectin benzoate), T₆ (Triazophos), T₇ (Cartap hydrochloride), T₃ (Dimethoate) and T₄ (Profenophos) already showed 100 per cent mortality up to 48 hrs of spraying (Table 19).

CHAPTER II

REVIEW OF LITERATURE

Watermelon is attacked by various pests. Among them, Pumpkin caterpillar *Diaphania indica* (saunders) (Lepidoptera: Pyralidae) is one of the most destructive pests of watermelon in late stage of the crop growth in our country. The references are available on various aspects related to the biology however, very scanty references are available on its chemical control hence various reviews on similar aspect related to some other leaf eating caterpillar pests have been included and presented in this chapter under the following headings:

2.1 To study the biology of watermelon Pumpkin caterpillar, *D. indica*.

2.2 To know the relative efficacy of different insecticides for the management of Pumpkin caterpillar, *D. indica* under laboratory conditions.

2.1 To study the biology of watermelon Pumpkin caterpillar *D. indica*:

Patel and Kulkarny (1956) reported *Margaronia indica* (Saunders) is an important pest of cucurbits in Bombay State. They recorded egg, larval and pupal stages lasted 4-6, 11-14 and 5-13 days at daily temperatures ranging from about 68 to 84°F .and 3, 9-12 and 5-6 days at a constant temperature of about 87°F. At a mean temperature of 81°F., males and females lived for 3-5 and 3-7 days, respectively, and the latter, who were more numerous than the males, laid 22-366 eggs each.

Reid and Cuthbert (1956) studied the biology of *Diaphania nitidalis*. They found Oviposition occurred at night, chiefly after fruiting began, and very few adults were seen in cultivated fields during the day, they probably shelter on trees and high bushes near the fields. The larval and pupal stages and complete development lasted 9-28, 6-31 and 22-53 days, respectively, in field cages.

Ba-Angood (1979) observed that at fluctuating temperatures of 25–35.9 °C, the egg, larval and pupal periods of *Diaphania indica* were 3.5, 11.5 and 6.2 d, respectively.

Mendes and Filho (1981) studied the biology of *Diaphania nitidalis* (Stoll), an important pest of cucurbits in Brazil and observed that the egg stage lasted for 3-4 days, the five larval instar averaged about 1, 2.2, 2.04, 1.78, and 2.62 days, respectively; the prepupal stages lasted for 1-2 days; the pupal stage lasted for 8-11 days for males and 8-12 days for females. The adults paired during the night of emergence and the pre oviposition period lasted for 1-3 days. Females ovipositor for 1-7 days (average 3.97 days) and laid an average of 236.64 eggs each. In the laboratory, adult males and females that had paired lived for 2-13 and 6-7 days, respectively.

KE *et al.* (1986) studied the pyralid, *Diaphania indica* (Saund.), a serious pest of cucurbitaceous vegetables of Zhejiang, China and observed that the mating took place at round midnight on the day of adult emergence and on an average 510 eggs were laid by a female in August and 340 in September with a maximum of 1053 eggs per female.

Posado (1992) made observations on the life cycle of *D. hyalinata* on melons in the laboratory at 26.8°C and 84 per cent

relative humidity and in the field in Colombia. The viability of eggs was 98.4 per cent, with an incubation period of 3 days. There were 5 larval instars lasting 12.3 days. The prepupal and pupal stages lasted 2.0 and 7.8 days, respectively and development from egg to pupa took 23.2 days. First instar larva did not feed on fruits, while 5th instar larvae perforated the rind and consumed the flesh.

Pozo (1994) studied the biology of *Diaphania hyalinata*, a pest of cucurbits in the laboratory of Cuba. The pest had 5 larval instars which could be differentiated without difficulty by measuring the head capsule.

Ganehiarachchi (1997) studied biology of *D. indica* on snake gourd. He observed female laid eggs two days after The incubation period at room temperature was 3-5 days. The larval period was 8-10 days and pupal period was 7-9 days. The maximum longevity of adult is 9 days.

Korgaonkar **(1999) conducted** a laboratory experiment on the biology of little gourd leaf eating caterpillar, *Diaphania indica*, revealed that the pre-oviposition, oviposition and post-oviposition periods averaged 2.0, 5.1 and 1.5 days, respectively. A female laid an average of 187.1 eggs. The average egg, larval, prepupal and pupal stages lasted for 4.75, 11.9, 1.3 and 9.4 days, respectively. The female to male sex ratio was 1.08:1. The longevity of adults varied from 8.45 to 9.0 days.

Prabhakar and Roy (2009) studied the life cycle and life table of Cucumber caterpillar, *Diaphania indica* Saunders, a serious pest of cucumber of the north-eastern part of Bihar (India). The net reproductive rate (R) was recorded as 56.446 and one generation was completed in 39.556 days. The expectation of

future life at the 45 days of pivotal age was reduced to 0.485 day from 8.342 days in the beginning.

Hosseinzade *et al.* (2013) studied the effect of different temperatures on the development of *D. indica* on cucumber. They recorded incubation period of eggs were 4.00 days and 1.76 days, 1.41 days, 1.69 days, 1.74 days, 1.79 days were required for completion of 1st, 2nd, 3rd, 4th, 5th instar respectively at 25 °C. incubation period of eggs were 3.32 days and 2.25 days, 1.47 days, 1.58 days, 1.75 days, 2.05 days were required for completion of 1st, 2nd, 3rd, 4th, 5th instar respectively at 30 °C. They recorded pre pupal and pupal period as 1.80 days and 7.90 at 25 °C respectively and 1.89 days and 6.09 days at 30 °C respectively.

Barma and Jha (2014) studied biology of leaf roller larvae studied under laboratory condition done at temperature varying between 30 and 35°C showed that the two temperature regimes had little effects on duration of different developmental stages. The total developmental period was 16 to 22 days (20.3±1.76 days) in 30°C and 17 to 22 days (19.5±1.43 days) in 35°C.

Panthi *et al.* (2016) reported that *Diaphania hyalinata* L. (Lepidoptera) is one of the serious insect problem affecting cucurbit production. They evaluated the relative preference and suitability of yellow squash, zucchini, cucumber, and watermelon to melon worm by measuring its oviposition, larval feeding preference, survivorship, and developmental responses in the laboratory. Watermelon feeding resulted in the longest larval development period (14.3 days), greatest

prepupal weights and survivals rates (92%; first instar to adult) among the four crops.

2.2 To know the relative efficacy of different insecticides for the management of Pumpkin caterpillar *D. indica* under laboratory conditions.

Peter and David (1989) carried a field trial with twelve insecticides on *Coccinia indica* at Padappai in Tamil Nadu. Toxicity of these insecticides to the third instar larvae of *Diaphania indica* was evaluated for immediate toxicity on the basis of larval mortality in 24 hr on *Coccinia* leaves carrying fresh dry film of insecticides. Cypermethrin was found superior against the larvae of *Diaphania indica* followed closely by deltamethrin and fenvalerate. Triazophos, phosalone and carbaryl were equally good in persistence as well as initial toxicity. Methomyl and quinalphos were found to have good immediate toxicity but not persistence.

Webb (1993) reported a combination of detergent and *Bacillus thuringiensis* was more effective than endosulfon for control of pickleworm and melon worm infesting squash.

Radhakrishnan and Natarajan (2009) reported with the help of Pooled mean analysis that yellow sticky trap + Dimethoate 30 EC @ 2 ml lit⁻¹ and yellow sticky trap + methyl Demeton 25 EC @ 2 ml lit⁻¹ were superior over other treatments in checking pumpkin caterpillar population during both the seasons.

Jyothsna **et al. (2013) reported** Among the different newer molecules, flubendiamide 480 SC at 60 g a.i. ha⁻¹,

combination product of flubendiamide 480 SC + thiacloprid 240 SC at 48 + 48 g a.i. ha⁻¹ and lambdacyhalothrin 5 SC at 18.75 g a.i. ha⁻¹ recorded high per cent reduction of *D. indica* population to 65.50, 62.12 and 59.22 per cent, respectively when compared to lambdacyhalothrin 5SC + thiamethoxam 25 WG at 15.625 + 31.25 g a.i. ha⁻¹ (50.96%), indoxacarb 14.5 SC at 21.75 g a.i. ha⁻¹ (47.87), Triazophos 40 EC at 500 g a.i. ha⁻¹ (45.67%), thiacloprid 240 SC at 120 g a.i. ha⁻¹ (37.95%), thiamethoxam 25 WG at 31.25 g a.i. ha⁻¹ (18.51%), and azadirachtin 0.15 EC at 1500 ppm (15.75%) after third spray. Thus flubendiamide 480 SC (60 g a.i. ha⁻¹) was adjudged as the best and effective treatment in checking *D. indica* population.

Sufficient references on efficacy of different insecticides for ***D. indica* are not available so other references of efficacy of insecticides for lepidopteron pests are mentioned here, they are as follows:**

Ahmed *et al.* (2012) reported that the leaf eating caterpillar, *Cricula trifenestrata* Helfer, a saturniid wild silk infests some plant *Persea bombycina* Kost. causing non-availability of quality leaves during commercial rearing seasons of muga silkworm. Efficacies of different chemical pesticides were evaluated and observed that Endosulfan (0.05% and 0.1%) caused the highest larval mortality of *C. trifenestrata* besides rendering the highest residual toxic effect to muga silkworm. Deltamethrin (0.0014% and 0.0028%) and Azadirachtin (0.0015% and 0.003%) were found effective against *C. trifenestrata* with the lower residual effect to muga silkworm after 15 days of treatment.

Hole *et al.* (2009) evaluated the bio-efficacy of cypermethrin, dichlorvos, endosulfan, profenophos and

quinalphos against *Spodoptera litura* infesting soybean. The pooled data showed that all the insecticidal treatments were significantly superior over untreated control in reducing the larval damage. The treatment with profenofhos 0.1% gave maximum protection when recorded up to 7 days after application. The highest residual toxicity to tobacco caterpillar recorded at 24, 48, 72 hrs and one week after application was exhibited in the treatment of profenofhos 0.1% under laboratory to field weathered deposits. Among the different insecticidal treatments tested in field, profenofhos 0.1% alone showed significantly superiority in controlling larval population.

Kumar *et al.* (2015) reported bioefficacy of nine modern insecticides under field condition against *S. litura* on groundnut, which revealed that emamectin benzoate 0.005 per cent, chlorpyrifos 0.05 per cent, cypermethrin 0.016 per cent and chlorantraniliprole 0.006 per cent were found to be the most effective.

Brundakumari *et al.* (2015) reported that drumstick was grown for pod as well as foliage yield and it was mainly attacked by leaf eating caterpillar, *Noorda blitealis* Walker. Ten insecticides were tested against the defoliator, *N. blitealis*. Indoxacarb 15.8 EC @ 0.3 ml/l, emamectin benzoate 5 SG @ 0.25 g/l and fipronil 5 SC @ 1 ml/l were effective throughout the period of investigation being on par with each other but superior over thiodicarb 75 WP @ 2 g/l, NSKE @ 5%, *Beauveria bassiana* 1.15 SP @ 2 g/l, deltamethrin 2.8 EC @ 0.5 ml/l, malathion 50 EC @ 2 ml/l and dichlorvos 76 EC @ 0.5 ml/l. Significantly maximum leaf yield was obtained from the treatments indoxacarb 15.8 EC @ 0.3 ml/l, emamectin benzoate 5 SG @ 0.25 g/l and fipronil 5 SC @ 1 ml/l (28.55, 27.60 and 27.45

t/ha, respectively). The next best treatments were deltamethrin 2.8 EC @ 0.5 ml/l (18.63 t/ha), Malathion 50 EC @ 2 ml/l (18.55 t/ha) and NSKE @ 5% (19.02 t/ha) and were on par with each other. The treatment indoxacarb 15.8 EC @ 0.3 ml/l recorded maximum additional yield (174 t/ha).

Mandal *et al.* (2015) conducted an experiment to study on the evaluation of insecticides for the management of bihar hairy caterpillar (*Spilosoma obliqua* Walk.) in black gram. Insecticides used in the experiment were azadirachtin 1500ppm @3ml/l, endosulfan 35EC @ 300g a.i/ha, triazophos 40 EC @ 250g a.i/ha, thiamethoxam 25 WG @ 40g a.i/ha, ð-cyhalothrin 5 EC @ 40g a.i/ha, indoxacarb 14.5 SC @ 75g a.i/ha and imidacloprid 17.8 SL @ 30g a.i/ha. Two sprays of insecticides were applied at fifteen days interval. The most effective insecticide in controlling the borers was triazophos followed by ð-cyhalothrin. Per cent reduction of hairy caterpillar over untreated plot after final sprays was followed this order of efficacy: triazophos (90.64%) > ð-cyhalothrin (83.71%) > indoxacarb (78.76%) > endosulfan (69.53%) > imidacloprid (62.31%) > thiamethoxam (57.40%). Azadirachtin was found to be least effective in controlling of hairy caterpillar.

Babariya *et al.* (2010) reported that among the different insecticides tested for chemical control of gram pod borer, *H.armigera* infesting pigeonpea, indoxacarb 0.0075% gave the highest per cent mortality of the pest followed by spinosad 0.009%, Profenophos + cypermethrin 0.044% and endosulfan 0.07%. Indoxacarb 0.0075% recorded significantly highest grain yield (1486 kg/ha). While, highest cost benefit ratio of 1: 18.94 was obtained from the treatment of endosulfan 0.07%.

Carneiro et al. (2014) tested Insecticides from different chemical groups by laboratory bioassay to verify the percentage mortality of *Helicoverpa armigera* (Hubner 1808) (Lepidoptera: Noctuidae). The populations utilized came from the University's own insect breeding laboratories. Third instar larvae of *H. armigera* were used to conduct the bioassay. The experimental design was fully randomized, with 13 treatments and four replications. Five larvae were used per replication, with 12 insecticides from 9 different chemical groups and a control. Each treatment consisted of three doses. The methods of application used were topical contact and ingestion in artificial diet. According to the results the percentage mortality of *H. armigera* larvae varied among the treatments. The results demonstrated that chlorpyrifos and spinosad were effective against third instar *H. armigera* larvae both on contact and by ingestion. flubendiamide, acephate, methomyl, *Bacillus thuringiensis*, dimethoate, chlorantraniliprole and fipronil had good responses to control of *H. armigera*.

Khorasiya and et al. (2014) conducted a field experiment to determine the efficacy of different insecticides against gram pod borer, *Helicoverpa armigera* (Hübner) infesting pigeon pea at Junagadh Agricultural University campus, Junagadh during *Kharif-Rabi* season of 2006-07. The results revealed that indoxacarb 0.007 per cent, spinosad 0.005 per cent and emamectine benzoate 0.005 per cent were found to be the most effective in reducing the gram pod borer population. The treatment of indoxacarb 0.007 per cent was found most economical as it gave the highest cost benefit ratio (1:7.546) followed by endosulfan 0.07 per cent (1: 6.766), cypermethrin 0.006 per cent (1: 5.492), novaluron 0.01 per cent (1: 5.376).

Yogeeswarudu and Venkatakrishna (2014) conducted Field trials in randomized block design with three replications of seven treatments during *Rabi* season 2012-13. Efficacy of different treatments *viz.*, indoxacarb 14.5 SC @ 0.5 ml/l, profenofos 50 EC @ 2.0 ml/l, imidacloprid 17.8 SL @ 1 m/l, novaluron 10 EC @ 1.5 ml/l, fipronil 5 SC @ 2.0 ml/l and lambda cyhalothrin 5 EC @ 1 ml/l was tested against *Helicoverpa armigera* larvae. The results revealed that indoxacarb 14.5 SC @ 0.5 ml/l was found best with minimum population of *H. armigera* at first spray.

CHAPTER V

SUMMARY AND CONCLUSION

Laboratory studies on biology of pumpkin caterpillar, *D. indica* revealed that the female usually laid eggs singly or in clusters of two or more during night time mostly on tender leaves, stalks. Eggs were also observed on the glass wall and muslin cloth. The freshly laid eggs were white to yellowish in color and elongated in shape. The eggs measured 0.87 mm in length and 0.57 mm in breadth. At the hatching egg became orange in colour. Pre-oviposition, oviposition and post-oviposition period was 2.2 days, 4.4 days, and 1.6 days. The total number of eggs laid by female in her life span varied from 116 to 308 with an average of 193.4 and incubation period was 4.3 days with 100 per cent hatching.

Larvae folded and webbed together the leaves and fed within. Larval development was completed within 13 days on watermelon and 11 days on pointed gourd. During this larva pass through five instars, the duration of these five instars lasted for 2 days, 3 days, 2 days, 3 days, 3 days on watermelon and 2 days, 3 days, 2 days, 2 days, 3 days on pointed gourd, respectively. Freshly emerged larva measured 1.2 mm in length and 0.14 mm in breadth on watermelon 1.83 mm in length and 0.24 mm in breadth on pointed gourd. Full grown larva measured 15.92 mm in length and 1.63 mm in head breadth on watermelon and 15.47 mm in length and 1.36 mm in head breadth on watermelon. Prepupal period lasted for 2.17 days on watermelon and 2.12 days on pointed gourd. The full grown larva pupated in silken cocoon on lower surface of leaf. Pupa was obtect and brown. Pupal period lasted for 6.71 days on

watermelon and 6.19 days on pointed gourd. An adult was medium sized, stoutly built with white wings which have an iridescent purplish reflection and brownish border. Proboscis was well developed, long and coiled. Antennae filiform. Longevity of male and female lasted for 6.8 days and 8.6 days, respectively on watermelon and 6.2 days and 7.8 days respectively on pointed gourd. Abdomen of male moth was slightly smaller than that of female moth. Adult moths had a brush like tuft of yellowish orange coloured hairs at their anal end. This brush was smaller in case of males. In male, there was a black dot in the centre of yellowish orange brush. The dot was absent in case of female. In female there was a receiving organ at the centre of brush ventrally. The moths frequently can be seen holding their brushes above the body level and slowly waving them in a circular fashion. Sex ratio of male to female was 1:4 on watermelon and 1:5.6 on pointed gourd. Total life cycle was completed in 33.53 days on watermelon and 30.66 on pointed gourd.

A laboratory experiment was conducted to study the effectiveness of some insecticides against Pumpkin caterpillar, *D. indica* on Watermelon. Post spray observations were recorded with an interval of 24, 48 and 72 hours after spraying. Treatments T₁ (Emamectin benzoate), T₆(Triazophos) and T₇(Cartap hydrochloride) showed 100 per cent mortality at 24 hrs after spraying and all these treatments were at par with each other. At 48 hrs of spraying, the treatments T₃ (Dimethoate) and T₄ (Profenophos) recorded 100 per cent mortality and both these treatments were at par with each other. After 72 hrs spraying the treatment T₅ (Azadirachtin) recorded 79.99 per cent mortality and which was found to be at par with treatment T₂

(Acetamiprid) which showed 76.67 per cent mortality. The treatment T₈ (control) showed no mortality.